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(71) Applicant : CANON KABUSHIKI KAISHA
30-2, 3-chome, Shimomaruko,
Ohta-ku
Tokyo (JP)

(72) Inventor : Takahashi, Kazuhiro, c/o Canon K. K.
30-2, 3-chome Shimomaruko,
Ohta-ku
Tokyo (JP)

(74) Representative : Beresford, Keith Denis Lewis et al
BERESFORD & Co.
2-5 Warwick Court
High Holborn
London WC1R 5DJ (GB)

(54) Exposure apparatus and device manufacturing method.

(57) A projection exposure apparatus includes a projection optical system for projecting a pattern of a first object (5) onto a second object (8) ; a laser source (1) ; an optical integrator (3) for forming a secondary light source from the laser source (1) ; and a condenser optical system (4) comprising cylindrical lenses (4a,4b) for imaging the secondary light source behind the first object (5) at different points on optical axis (X) in the X-Y and X-Z planes.

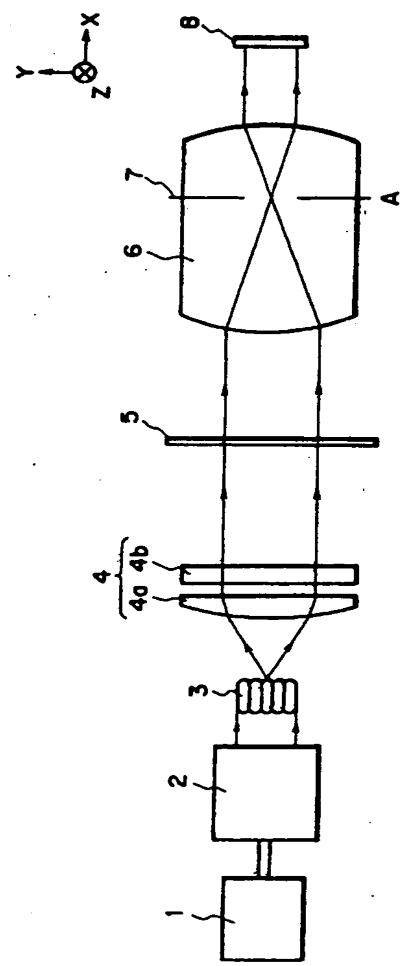

FIG. 1

EP 0 668 541 A1

Jouve, 18, rue Saint-Denis, 75001 PARIS

FIELD OF THE INVENTION AND RELATED ART

The present invention relates to a projection exposure apparatus and a device manufacturing method for manufacturing various devices using the projection exposure apparatus, usable for manufacturing a semiconductor device such as IC or LSI, a display device such as liquid crystal panel, a magnetic head or the like.

Recently, the density of the semiconductor device such as IC or LSI is acceleratedly increased, and the resultant development for the fine processing for a semiconductor wafer is also remarkable. The projection exposure technique which is the key part of the fine processing, is under development for increase of the resolution to form an image of a dimension not more than 0.5 μm. The increase of the resolution is directed, in the projection exposure optical system, is directed to increase of NA (numerical aperture) or decrease of the wavelength of the exposure beam.

With the decrease of the wavelength of the exposure light, the transmissivity of the glass material decrease, and therefore, the kinds of the glass material usable for the projection optical system decreases in the number. When the number of kinds of the glass material, the correction of the chromatic aberration becomes difficult, and therefore, it is desired to reduce the wavelengths band width of the light source to such an extent that the resultant chromatic aberration is negligibly small. For example, in the projection optical system using the light having a wavelength of 300 nm or less, the usable glass materials are quartz and fluorite, and the light source provides narrow band laser beam. When a laser is used as a light source, a plurality of spots are formed on a pupil of the projection optical system from a single spot to which the laser beam is condensed, since the laser beam has high directivity. The energy density is very high in the spot, and when an optical element is disposed at this position, the glass material or coating thereof is deteriorated by the laser spot, or damaged by long term illumination. If this occurs, the transmissivity of the glass material decreases, and the property of the coating is changed. In order to avoid this problem, it would be considered that the lens or a concave mirror is not disposed adjacent the pupil plane of the projection optical system.

However, when the NA of the optical system is increased for the purpose of increasing the resolution, or when the size of the field of the image is increased, with the result of increase of the number of lenses constituting the optical system, it is difficult to provide a space without an optical element in the neighborhood of the pupil plane.

SUMMARY OF THE INVENTION

Accordingly, it is a principal object of the present invention to provide a projection exposure apparatus and a device manufacturing method using the same in which the density of the energy of the laser beam condensed in the optical system can be reduced.

According to a first aspect of the present invention, there is provided a projection exposure apparatus and a device manufacturing method including a projection optical system for projecting a pattern of a first object onto a second object, and an illumination system for illuminating the pattern on the first object, wherein the illumination optical system includes a laser beam source and an illumination optical system for illuminating the surface of the first object with the beam from the laser source and for condensing the light beam from the laser source at different plural positions in the optical axis direction of the projection optical system, behind the first object plane. Thus, the surface of the first object is illuminated with the laser beam, and the laser beam is condensed at the positions different in the optical axis direction of the projection optical system, and therefore, the laser beam does not form a spot adjacent the pupil plane, thus reducing the energy density of the laser beam so that the durability of the apparatus is improved.

According to a second aspect of the present invention, there is provided a projection exposure apparatus comprising: a projection optical system for projecting a pattern of a first object onto a second object; a laser source; an optical integrator for forming a secondary light source from the laser source; and a condenser optical system for imaging the secondary light source behind the first object at positions different in a direction of an optical axis with respect to two different directions to illuminate the first object therewith.

The surface of the first object is illuminated by the beam from the secondary light source, and the beam from the secondary light source is focused at positions different in the optical axis direction in two different direction, behind the first object surface, by the condenser optical system. Since the surface of the first object is illuminated by the beam from the secondary light source of the optical integrator, and therefore, the first object surface can be illuminated with uniform illumination intensity. In addition, the laser beam is prevented from forming a spot adjacent the pupil plane. Thus, the energy density of the laser beam is reduced, and therefore, the durability of the apparatus is improved.

According to a third aspect of the present invention, there is provided a projection exposure apparatus comprising: a projection optical system for projecting a pattern of a first object onto a second object; a laser source; an optical integrator for forming a secondary light source from rays of the laser source; a condenser lens for illuminating the first object with rays from the secondary light source; wherein the optical integrator comprises a plurality of lenses dis-

posed such that rear focus positions are a predetermined distance away from each other in two orthogonal directions, wherein the rays are condensed behind the first object at positions different in a direction of an optical axis in the two directions through the condenser optical system.

According to this feature, the surface of the first object is illuminated by the beam from the secondary light source of the optical integrator, and therefore, the surface of the object can be illuminated with uniform illumination intensity. By preventing spot formation of the laser beam adjacent the pupil plane, the energy density of the laser beam is reduced, so that the durability of the apparatus is increased. Additionally, since the plural light sources for providing the secondary light source has a linear configuration, it is effective to form an illumination area in the form of a slit.

According to a fourth aspect of the present invention, there is provided a projection exposure apparatus and a device manufacturing method, including a projection optical system for projecting a pattern of a first object onto a second object, and an illumination system for illuminating the pattern on the first object, and the illumination system includes a laser light source as a light source, and an illumination optical system or condensing the beam from the laser source at positions different in the optical axis direction of the projection optical system to illuminate the first object surface, wherein a beam condensing position in a direction perpendicular to the scanning direction is on the pupil plane of the projection optical system, whereas the condensing position in a plane including the scanning direction is deviated from the pupil position of the projection optical system. In the plane including the scanning direction, the condensing position of the laser beam is deviated from the pupil plane of the projection optical system. The illumination beam (image formation beam) will be deviated (tilted) depending on the image height, but adjacent the optical axis of the projection optical system (in front of and at the back of the optical axis in the scanning direction), the scanning exposure is effected, by which the deviation of the illumination beam in the scanning direction is made even, so that the exposure can be effected without the deviation of the beam.

According to a fifth aspect of the present invention, the third aspect is improved in that a rear focus position in a direction perpendicular to the scanning direction of the optical integrator constituted by a plurality of lenses disposed such that the rear focus positions are deviated through a predetermined distance in the optical axis direction, in orthogonal two directions, is optically conjugate with the pupil plane of the projection optical system, and the rear focus position in the scanning direction is not in optical conjugation with the pupil plane of the projection optical system. In the plane including the scanning direction, the image position of the secondary light source provided by the optical integrator is deviated from the pupil plane of the projection optical system. Therefore, the illumination beam (imaging beam) is deviated (tilted) depending on the image height. The deviation can be made even in the scanning direction by effecting the scanning exposure adjacent the optical axis of the projection optical system (in front of and at the back of the optical axis in the scanning direction), by which the exposure is possible with the beam without the deviation.

According to a sixth aspect of the present invention, there is provided a projection exposure apparatus and a device manufacturing method, which includes a projection optical system for projecting the pattern on the first object onto the second object and an illumination system for illuminating the pattern of the first object, and the illumination system includes a laser source, and an illumination optical system for condensing the light beam from the laser source at positions different in the direction of the optical axis of the projection optical system behind the first object to illuminate the first object surface with the laser beam from the laser source, and the illumination optical system is effective to condense the beam from the laser source at a position of the pupil plane of the projection optical system and a position deviated therefrom. By doing so, the energy density of the laser beam can be increased by avoiding the spot formation adjacent the pupil plane, thus improving the durability of the apparatus. Additionally, the reduction of the imaging performance is avoided by placing one condensing position at the pupil plane.

According to a seventh aspect of the present invention, there is provided a projection exposure apparatus and a device manufacturing method, which comprises a projection optical system for projecting a pattern of a first object onto a second object and an illumination system for illuminating the pattern of the first object, and the illumination system includes a laser source and an illumination optical system for condensing the light beam from the laser source at positions different in the direction of the optical axis of the projection optical system, behind the first object surface to illuminate the surface of the first object with the beam from the laser source. By doing so, the spot formation of the laser beam is prevented adjacent the pupil plane, thus decreasing the energy density of the laser beam, by which the durability of the apparatus is improved, and by using an illumination optical system producing astigmatism, by which the beam from the light source is condensed into a linear shape at different positions, thus further reducing the energy density.

According to an eighth aspect of the present invention, the sixth and the seventh aspect are further improved in that the first and the second objects are scanned by the laser beam from the laser source so

that each part of the pattern of the first object is sequentially projected onto the second object, and an illumination optical system condenses the light from the laser source at a position of the pupil plane in a plane including the optical axis and a direction perpendicular to the scanning direction, and condenses the light from the laser source at a position away from the pupil plane in a plane containing the optical axis and the scanning direction. By doing so, the energy density of the laser beam can be reduced without reduction of the imaging performance.

These and other objects, features and advantages of the present invention will become more apparent upon a consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates an apparatus according to a first embodiment of the present invention in an XY plane.

Figure 2 shows the same in ZX plane.

Figure 3 shows a pupil plane of the projection optical system according to the first embodiment and an image of a secondary light source at a position a predetermined distance away from the pupil plane.

Figure 4 illustrates a second embodiment in XY plane.

Figure 5 illustrates the second embodiment in ZX plane.

Figure 6 illustrates a system according to a third embodiment in XY plane.

Figure 7 illustrates the system of the third embodiment in ZX plane.

Figure 8 shows an example of a projection optical system using refraction optical system according to an embodiment of the present invention.

Figure 9 shows an example of a projection optical system using reflection and refraction optical system according to an embodiment of the present invention.

Figure 10 is a flow chart for manufacturing a semiconductor device.

Figure 11 is a flow chart of wafer processing in Figure 10.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figures 1 and 2 schematically show a projection exposure apparatus usable for manufacturing semiconductor devices such as IC or LSI, image pickup device such as CCD, a display device such as liquid crystal panel, a magnetic head or the like, according to a first embodiment of the present invention. In Figures 1 and 2, the direction of the optical axis is represented by "X", and Figure 1 is a view in an XY plane, and Figure 2 shows the same in ZX plane.

In Figure 1, a substantially collimated laser beam emitted from the laser source 1 is incident on a device 2 for making the beam incoherent. In the device 2, the shape of the laser beam emitted from the laser source 1 is reformed to much the shape of the optical integrator 3, and divide or scan the laser beam so that no speckle pattern or another interference fringes, are formed on the wafer 8. The light passing through the device 2 is incident on the optical integrator 3 and is divided into a number of light beams thereby, into a number of scattering beams. In other words, the light emitting surface of the optical integrator 3 functions as a secondary light source, and a number of scanning beams from the secondary light source is incident on a condenser lens 4, which in turn are overlaid on the reticle 5 to effect uniform illumination.

The condenser lens 4 comprises a cylindrical lens 4a and 4b. In the XY plane, the lens 4a has a refraction power, but the lens 4b has no refraction power in this plane. The light rays from the secondary light source are overlaid on the surface, to be illuminated, of the reticle 5 by the condenser lens 4a. At this time, if the projection optical system 6 is a telecentric optical system, the principal ray of the illumination is incident on the reticle 5 in the form of afocal light, and forms an image of the secondary light source in the XY plane on a pupil plane 7 of the projection optical system 6. The reticle 5 has a circuit pattern of a semiconductor device to be transferred onto the wafer 8, so that the projection optical system 6 forms an image of the circuit pattern on the wafer 8, and therefore, the pattern image is transferred thereonto.

Figure 2 is a view in ZX plane (as seen perpendicularly to the sheet of the drawing of Figure 1), and the lens 4a of the condenser lens 4 is a cylindrical lens not having a refraction power in the XY plane, but it has a refraction power in the ZX plane. The light rays from the secondary light source in the emitting side surface of the optical integrator 3 are overlaid on the reticle 5 by the condenser lens 4b. The condenser lens forms an image of the secondary light source in the ZX plane at a position B away from the pupil plane 7 of the projection optical system 6 by a predetermined distance. Each principal ray of the illumination light incident on each point on the reticle 5, is parallel in the XY plane of Figure 1, but is inclined at a predetermined angle toward the optical axis in the ZX plane of Figure 2, so that the light is converged as shown in the Figure.

Figures 3A and 3B show images of the light source in a plane perpendicular to the optical axis at a position A at the pupil plane 7 (aperture position) of the projection optical system 6 and at a position B away from the position A. In Figure 3A, the light from the optical integrator 3 is converged in Y direction, but is diverged in the Z direction in a predetermined degree. On the other hand, in Figure 3B, it is converged

in the Z direction but is diverged in the Y direction, contrary to Figure 3A. The shapes of the secondary light source formed in the projection optical system 6 shown in Figures 3A and 3B, are dependent on the structure of the shape of the optical integrator 7 and the structure of the device 2.

As described, the projection exposure apparatus of this embodiment uses an anamorphic illumination optical system having different focal length in orthogonal two directions so that the astigmatism is provided for the formation of images of the secondary light source within the projection optical system, by which linear spots are formed at positions A and B. Thus, no spot is formed at any position in the projection optical system 6 by the light from the laser source, thus avoiding occurrence of high energy density projection. Therefore, the durability of the optical system 6 and therefore the apparatus is increased. This advantageous effect is provided in the other embodiments of the present invention.

Figures 4 and 5 illustrate a projection exposure apparatus usable for manufacturing devices such as a semiconductor device such as IC or LSI, an image pickup device such as CCD, a display device such as a liquid crystal device, a magnetic head or the like, according to a second embodiment of the present invention. In this embodiment, the scanning operation is effected in the direction indicated by an arrow in Figure 5 in synchronism with the reticle 5 and the wafer 8, so that the wafer 8 is exposed through the pattern of the reticle 5. Therefore, the present invention is applied to a scanning type exposure apparatus.

In the scanning type exposure apparatus, the shape of the illumination area on the wafer and on the reticle 5, is slit-like. The optical integrator 3 is constructed by a cylindrical lens or the like having different refraction power in the orthogonal two directions perpendicular to the optical axis, by which a plurality of slit-like light source is formed on the secondary light source surface. The longitudinal directions of the slit light source and the illumination area are made the same, by which the illumination area can be illuminated efficiently by the slit-like light.

In this embodiment, the optical integrator 3 is constituted by cylindrical lenses 3a and 3b. The cylindrical lens 3a has a refraction power in XY plane, and the light is collimated by a condenser lens 4a to illuminate in the longitudinal direction the slit like illumination area of the reticle 5. On the other hand, a cylindrical lens 4b has a refraction power in a ZX plane, and the condenser lens 4b is effective to illuminate the slit-like illumination area in a width (scanning direction).

In Figure 4, the secondary light source formed on the emitting surface of the optical integrator 3 is formed on a pupil plane of the projection optical system 6 by the condenser lens 4a in the XY plane.

In Figure 5, there is shown a positional relationship between the secondary light source and the pupil plane of the projection optical system 6 in the ZX plane including the scanning direction. In the ZX plane, the emitting surface of the optical integrator 3 is imaged at a position C which is predetermined distance away from the pupil plane 7 in the optical axis direction, by the condenser lens 4b. The image of the secondary light source on the pupil plane 7 in Figure 4 has the same distribution as shown in Figure 3A, and the image of the secondary light source at a position C in Figure 5, as the same distribution as in Figure 3B, in embodiment 1, so that there is no high energy density position resulting from converged spot image.

In Figure 5, if it is assumed that the projection optical system 6 is telecentric at a light emitting side (wafer 8 side), the principal ray is incident with an angle relative to the optical axis at positions D and E on the wafer. Generally, when the principal ray is incident with inclination, the size of the image changes if the wafer 8 is exposed with defocusing. However, in the embodiment of Figure 5, the sequential exposure is carried out while scanning in the direction of the arrow, and therefore, the inclination of the principal ray is uniformed by the scanning exposure from a position D to a position E, and therefore, the size of the image remains the same despite the defocusing.

Accordingly, when the present invention is used in the scanning type exposure apparatus, it is desirable that the secondary light source is imaged on the pupil plane of the projection optical system in a plane including the optical axis direction and a longitudinal direction of the slit (perpendicular to the scanning direction), and the image of the secondary light source is formed at a position a predetermined distance away from the pupil plane of the projection optical system in a plane including the scanning direction and the optical axis direction.

Figures 6 and 7 show a projection exposure apparatus usable for manufacturing devices such as a semiconductor device such as IC or LSI, an image pickup device such as CCD, a display device such as liquid crystal panel, a magnetic head or the like. The structures of the exposure apparatus are substantially the same as in the first and second embodiments, and therefore, only the optical system downstream of the optical integrator 3 is shown. In this embodiment, the condenser lens 4 in the illumination system comprises a rotation symmetry lens having uniform refraction power. The optical integrator 3 comprises a plurality of cylindrical lenses 3a and 3b so that the rear focus positions are deviated from each other in the direction of the optical axis by a predetermined distance, in orthogonal two directions.

Figure 6 is a view as seen in XY plane of the apparatus according to the third embodiment of the present invention. In Figure 6, the optical integrator 3A is in the form of a group of cylindrical lenses having

refraction powers in the XY plane to converge the laser beam from the laser source 1 at a rear focus position F. The optical integrator 3b does not have a refraction power in the XY plane, and is constituted by cylindrical lenses overlaid in the direction perpendicular to the sheet of the drawing. The condenser lens 4 has a focal length fc, and the projection optical system 6 is telecentric relative to the object (reticle) side. In this case, the rear focus position F is a distance fc away from the condenser lens 4. In this case, the secondary light source formed at the position F is formed on the pupil plane 7 of the projection optical system in the XY plane.

Figure 7 is a view as seen in ZX plane of the apparatus of the third embodiment. The optical integrator 3b has a refraction power in ZX plane, and the laser beam is condensed at a position of the rear focus position F' to form a secondary light source there. The rear focus position F' is (fc + X) away from the condenser lens. Therefore, the secondary light source in the ZX plane is imaged at a position a predetermined distance (xp) away from the pupil plane 7 of the projection optical system 6. Here, the following is satisfied:

$$xp = (fi/fc)^2 \times X$$

where fi is a focal length of the lens group 6a in front of the projection optical system 6.

Similarly to the first and second embodiments, the image of the secondary light source in the pupil plane 7 of the projection optical system 6 in Figure 6 is slit-like in the third embodiment, too. Additionally, the secondary light source image at the image position adjacent the pupil plane 7 in the ZX plane in Figure 7, is a slit-like, as shown in Figure 3B. Therefore, the laser beam is not condensed into a spot in the projection optical system 6.

When the third embodiment is used for a scanning type projection exposure apparatus in which the wafer 8 is scanned and exposed to the circuit pattern on the reticle 5 in synchronism therewith, the scanning direction is selected to be in accord with Z direction, by which the illumination light is uniformed with the result that the exposure can be effected with uniform light.

Figure 8 shows an example of a projection optical system used in the first, second and third embodiments. In this example, nine lenses 61 - 71 are used, and the pupil plane (aperture) 7 is in proximity with the lens 66.

Figure 9 shows another example of a projection optical system 6 usable with the first, second and third embodiments. The optical system shown in Figure 10 comprises lens groups 101 and 104, a concave mirror 103, and a beam splitter 102, which constitute a reflection and refraction optical system.

The light from the reticle 5 passes through the lens group 101 and the beam splitter 102 and is then reflected by the concave mirror 103. The light reflected by the concave mirror 103 is further reflected by the beam splitter 102 and is condensed on a wafer 8 by the lens group 104, so that the pattern of the reticle 5 is imaged on the wafer 8, in this optical system, the pupil plane (aperture plane) 7 is substantially in accord with the position of the concave mirror. In the projection optical system, the optical path is not folded by mirror or the like, but it is possible to fold the optical path using a mirror or mirrors.

According to the foregoing embodiments, the spot-like condensation of the laser beam can be avoided in a projection optical system in an exposure apparatus using a high directivity such as a laser, and therefore, the durability of the optical elements at or adjacent the pupil plane, for example, against the laser beam can be improved.

The description will be made as to an embodiment of device manufacturing method using the scanning exposure apparatus. Figure 10 is a flow chart of manufacturing semiconductor devices such as IC, LSI or the like, or devices such as liquid crystal panel or CCD or the like. At step 1, (circuit design), the circuits of the semiconductor device is designed. At step (mask manufacturing) 2, the mask (reticle 304) having the designed circuit pattern is manufactured. On the other hand, at step 3, a wafer (306) is manufactured using the proper material such as silicon. Step 4 (wafer processing) is called pre-step, in which actual circuit pattern is formed on a wafer through lithographic technique using the prepared mask and wafer. At step 5 (post-step), a semiconductor chip is manufactured from the wafer subjected to the operations of step 4. The step 5 includes assembling steps (dicing, bonding), packaging step (chip sealing) or the like. At step 6 (inspection), the operation of the semiconductor device manufactured by the step 5 is inspected, and durability test thereof is carried out. In this manner, the semiconductor device is manufactured and delivered at step 7.

Figure 11 is a flow chart of detailed wafer processing. At step 11 (oxidation), the surface of the wafer is oxidized. At step 12 (CVD), an insulating film is formed on a surface of the wafer. At step 13 (electrode formation), an electrode is formed on the wafer by evaporation. At step 14 (ion injection), the ion is implemented into the wafer. At step 15 (resist processing), a photosensitive material is applied on the wafer. At step 16 (exposure), the circuit pattern of the mask (reticle 304) is projected onto the wafer by the above-described exposure apparatus. At step 17 (development), the exposed wafer is developed. At step 18 (etching), the portion outside the resist image are removed. At step 19 (resist removal), the resist is removed after the etching. By repeating the above-described steps, overlaid circuit patterns are formed on the wafer.

According to the manufacturing method according to the embodiments of the present invention, the

integration density can be improved.

While the invention has been described with reference to the structures disclosed herein, it is not confined to the details set forth and this application is intended to cover such modifications or changes as may come within the purposes of the improvements or the scope of the following claims.

Claims

1. A projection exposure apparatus comprising:
a projection optical system for projecting a pattern of a first object onto a second object;
a laser source;
an optical integrator for forming a secondary light source from said laser source; and
a condenser optical system for imaging the secondary light source behind the first object at positions different in a direction of an optical axis with respect to two different directions to illuminate the first object therewith.

2. An apparatus according to Claim 1, wherein the condenser optical system has refraction powers different in orthogonal directions.

3. An apparatus according to Claim 1, wherein the first object and the second object are scanned with light, and an image of the secondary light source is formed adjacent a pupil of said projection optical system, and the image position in a direction perpendicular to the scanning direction is substantially in accord with the pupil, and the image position in the scanning direction is a predetermined distance away from the pupil of the projection optical system in the direction of the optical axis.

4. An apparatus according to Claim 1, wherein the optical integrator comprises a plurality of lenses each having different refraction powers in two orthogonal directions.

5. A projection exposure apparatus comprising:
a projection optical system for projecting a pattern of a first object onto a second object;
a laser source;
an optical integrator for forming a secondary light source from rays of the laser source;
a condenser lens for illuminating the first object with rays from the secondary light source;
wherein said optical integrator comprises a plurality of lenses disposed such that rear focus positions are a predetermined distance away from each other in two orthogonal directions, wherein the rays are condensed behind the first object at positions different in a direction of an optical axis in the two directions through said condenser optical system.

6. An apparatus according to Claim 5, wherein the first object and the second object are scanned with the rays, wherein rear focus positions of said optical integrator in a direction perpendicular to the scanning direction is in optical conjugation with a pupil of said projection optical system.

7. A projection exposure apparatus comprising:
a projection optical system for projecting a pattern of the first object onto the second object;
an illumination system for illuminating the second object with the pattern of the first object;
wherein said illumination system comprises a laser source, and condenses rays from the laser source at positions different in the direction of the optical axis of said projection optical system behind the first object to illuminate the first object therewith.

8. An apparatus according to Claim 7, wherein said illumination optical system condenses the rays at the pupil of the projection optical system and at a position away from the pupil in the direction of the optical axis.

9. An apparatus according to Claim 7, wherein said illumination optical system produces astigmatism.

10. An apparatus according to Claim 8, wherein the first and second objects are scanned with light, the rays are condensed at the pupil in a plane including a direction perpendicular to the scanning direction and the optical axis, and at a position away from the pupil in a plane including the scanning direction and the optical axis.

11. An optical system for imaging a source at different positions along the optical axis in different planes.

12. A projection exposure apparatus having an optical system in accordance with claim 11.

13. A device manufacturing method comprising a step of projecting a device pattern of the first object onto the second object using projection exposure apparatus as defined in any one of claims 1 to 10 and 12 and/or an optical system as defined in claim 11.

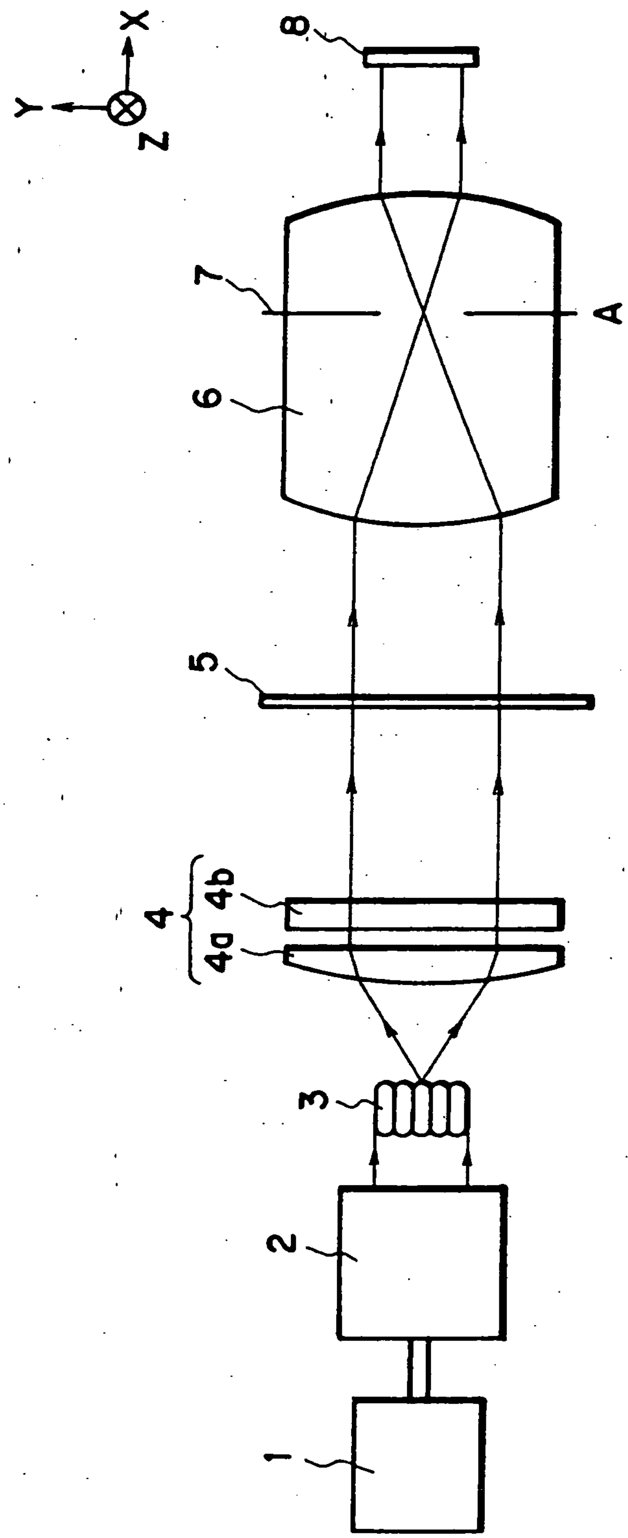

FIG. 1

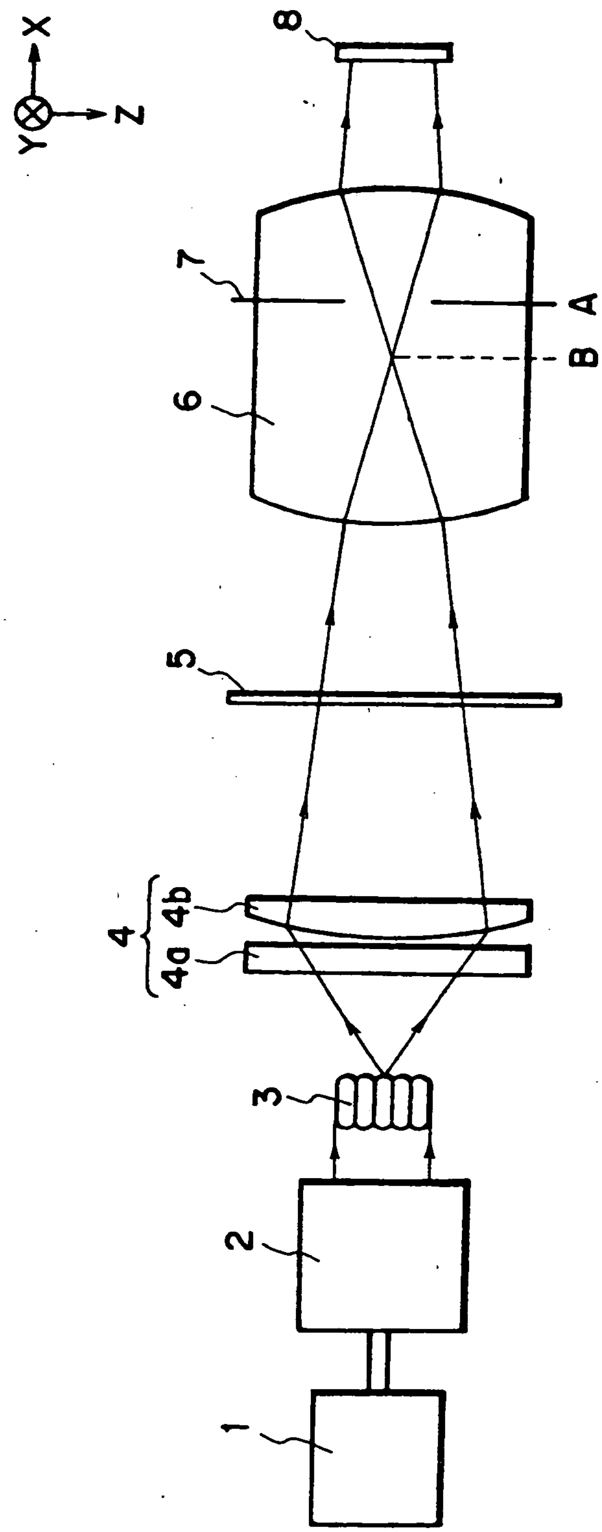

FIG. 2

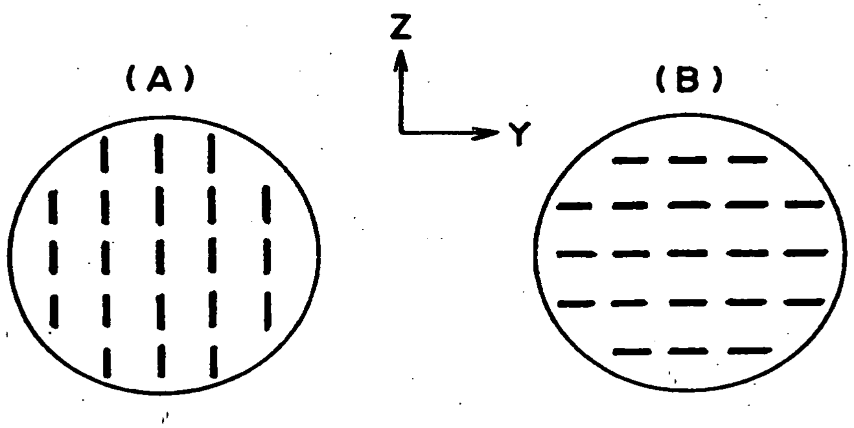

FIG. 3

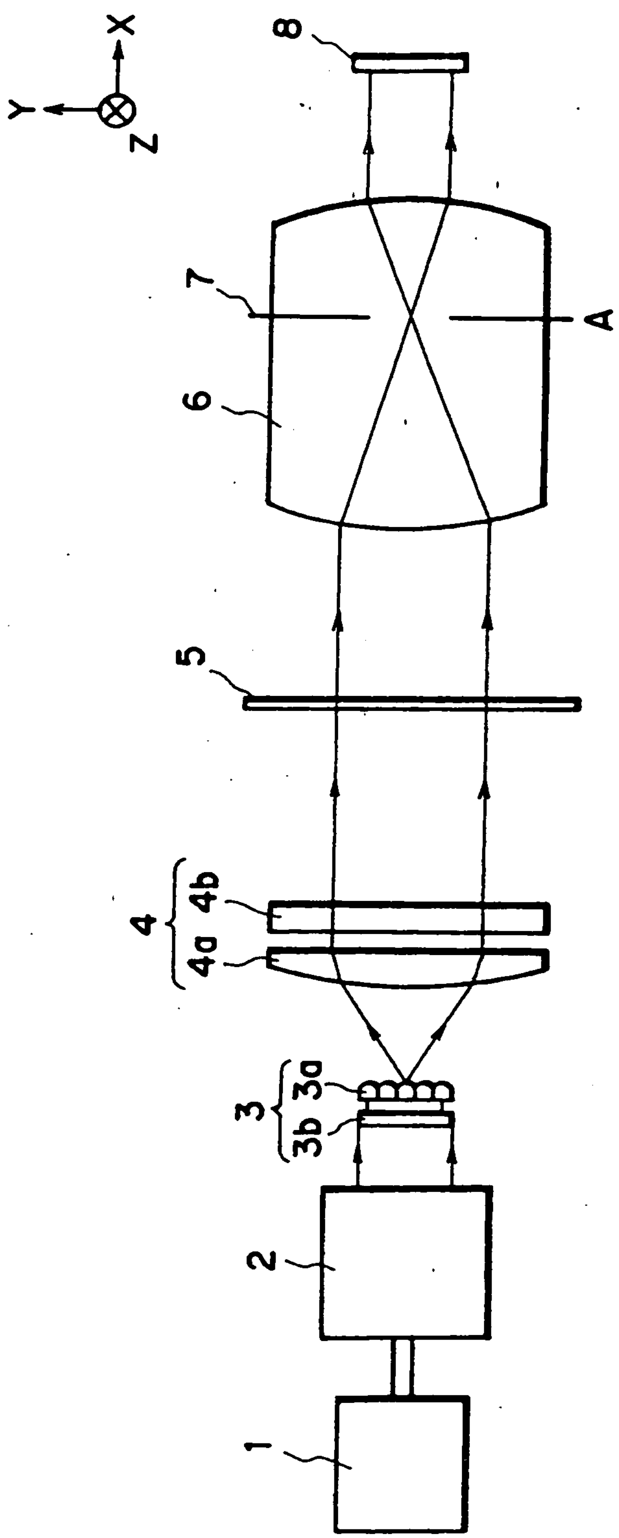

FIG. 4

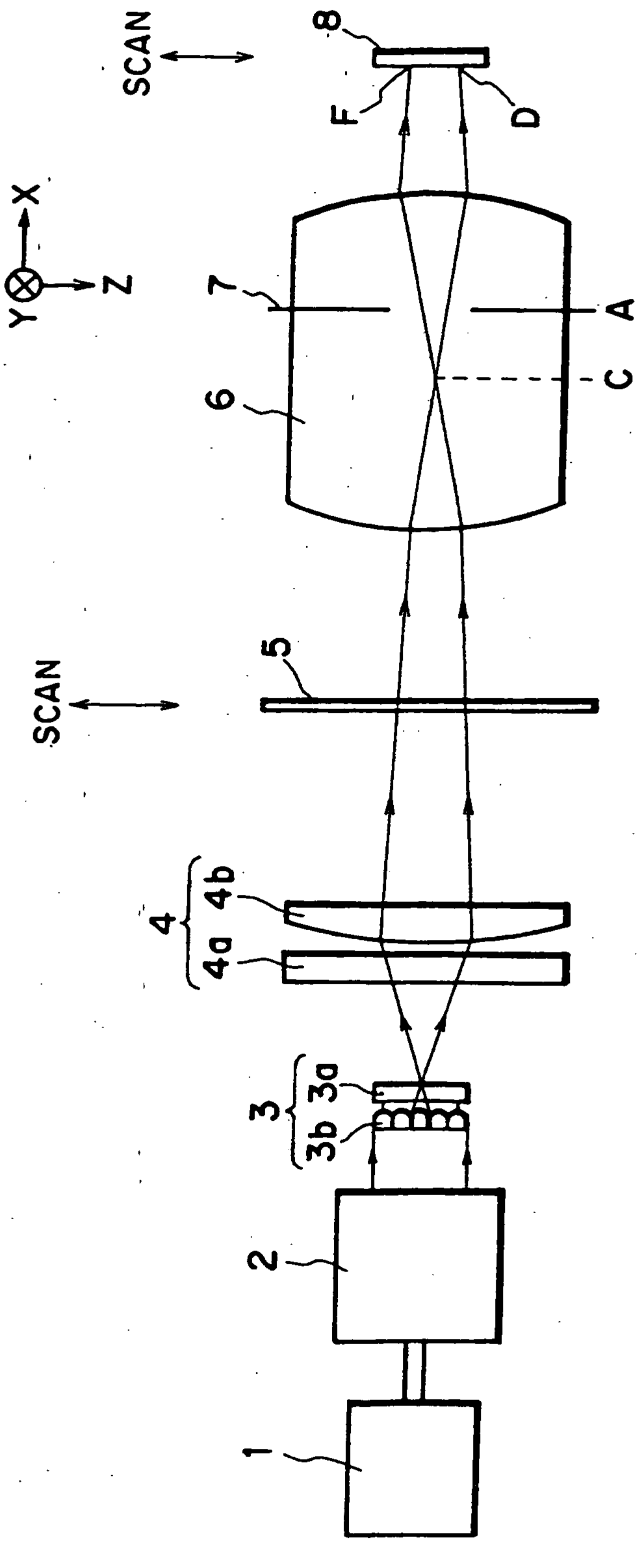

FIG. 5

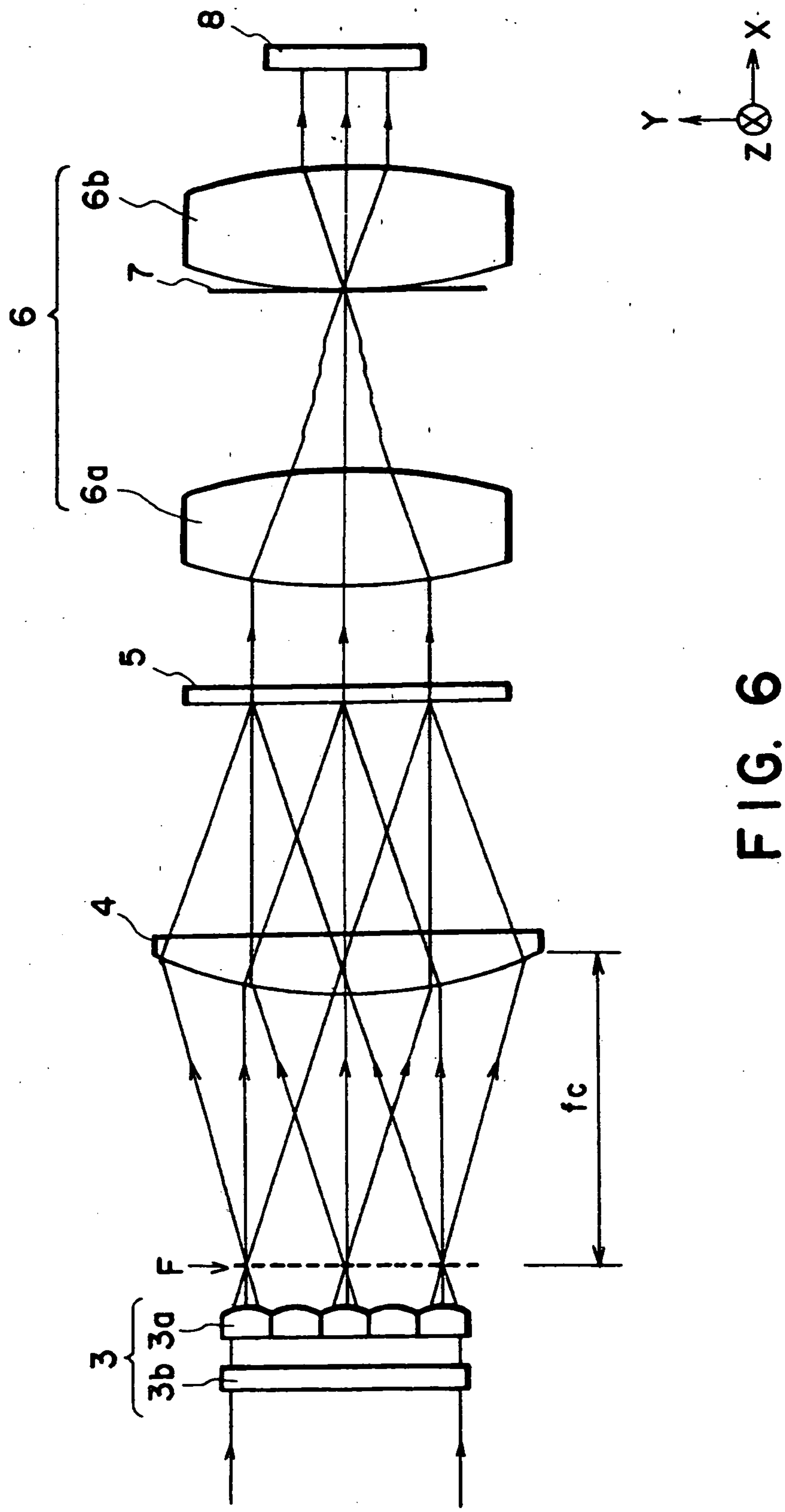

FIG. 6

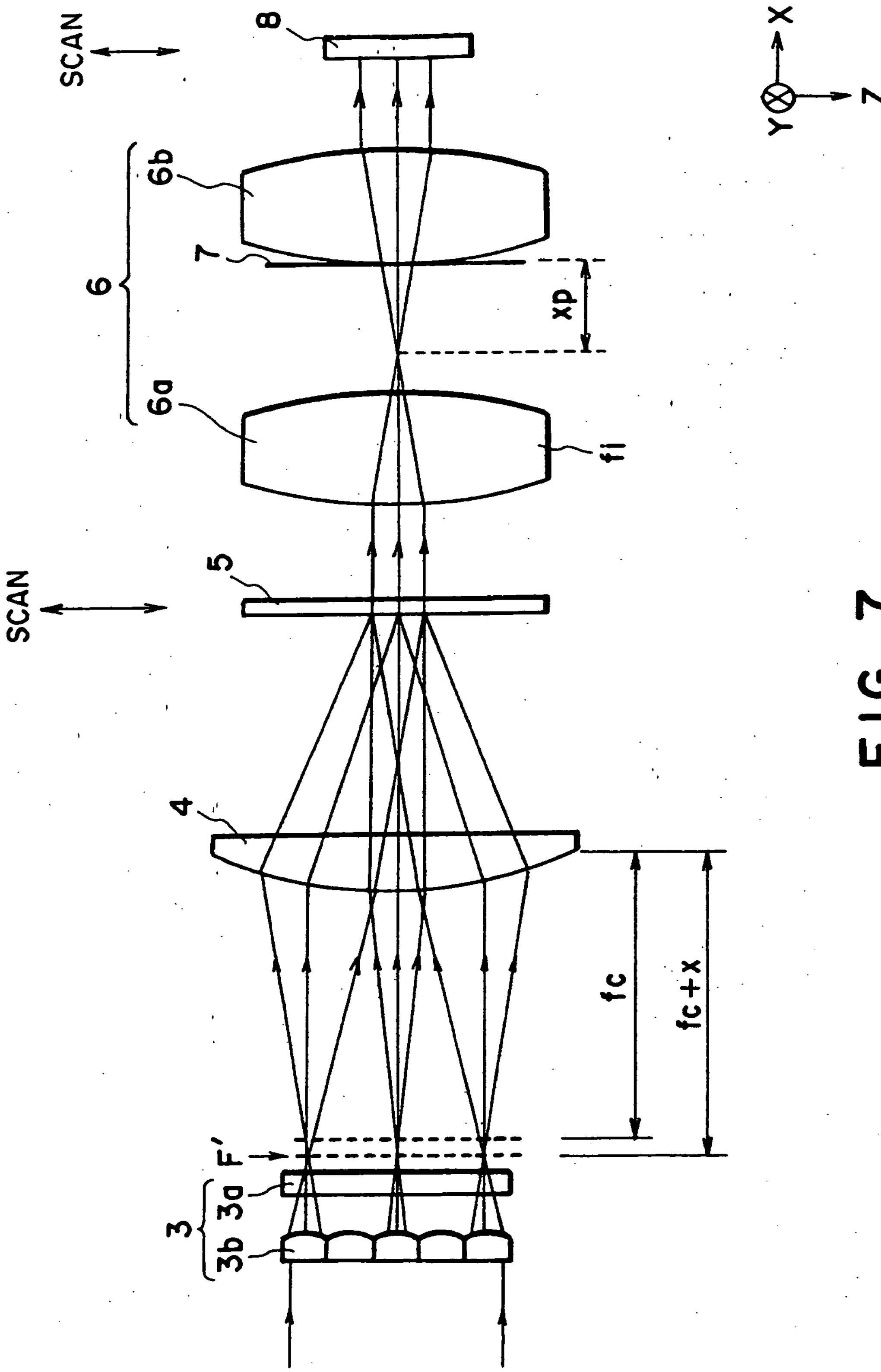

FIG. 7

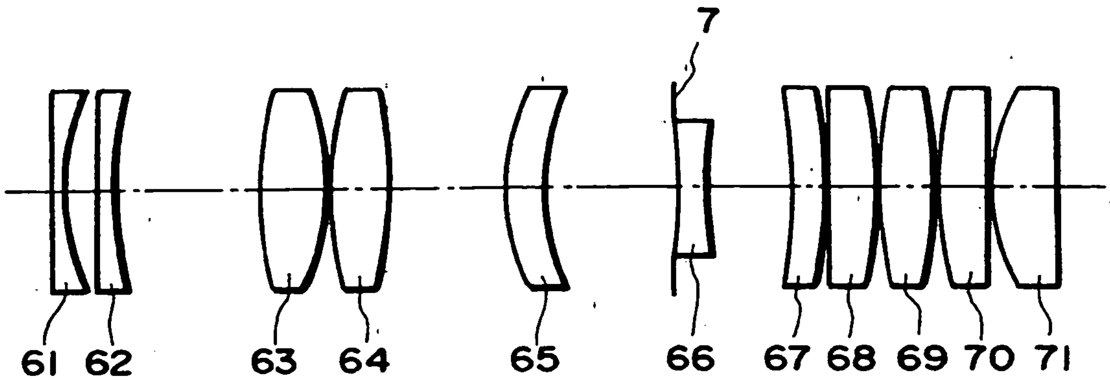

FIG. 8

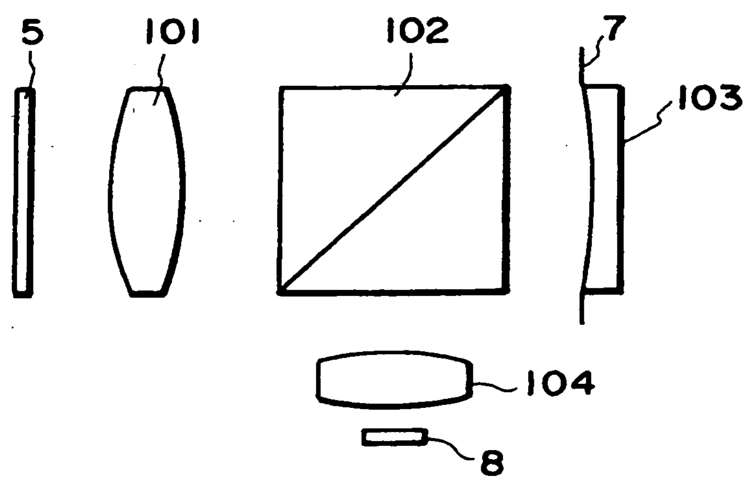

FIG. 9

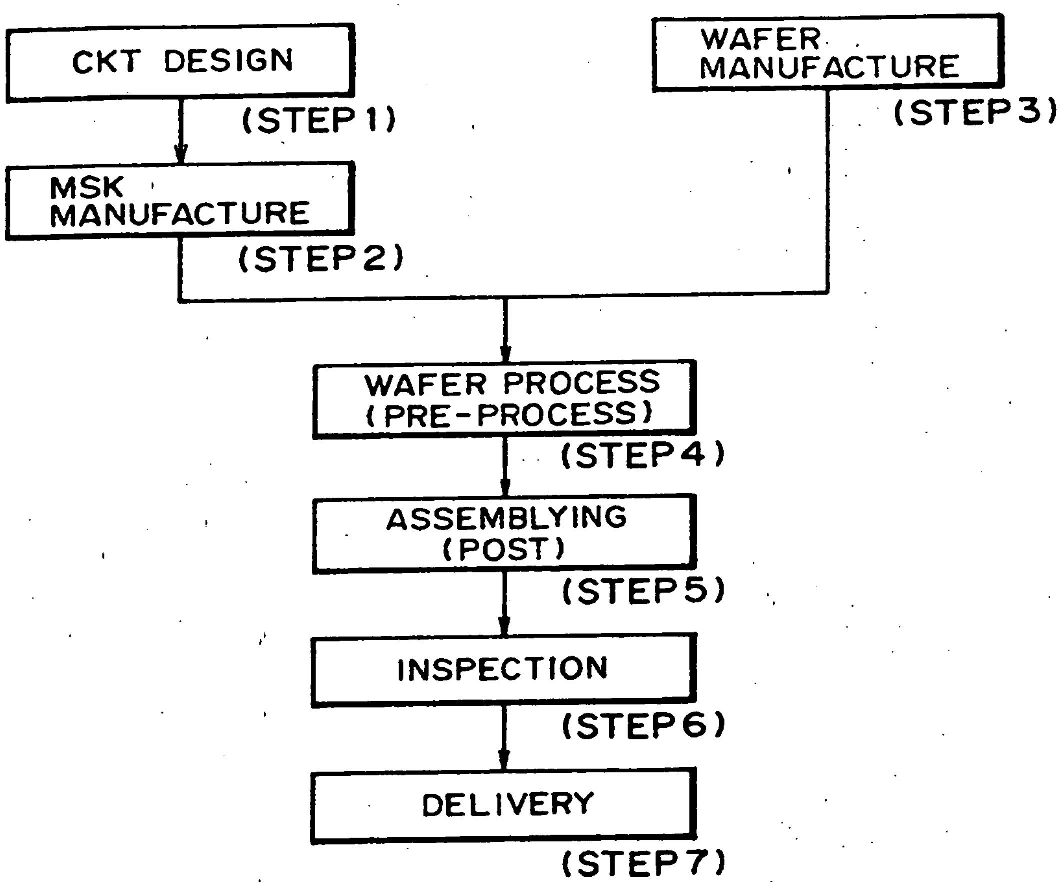
CKT DESIGN
(STEP 1)
MSK MANUFACTURE
(STEP 2)
WAFER MANUFACTURE
(STEP 3)
WAFER PROCESS (PRE-PROCESS)
(STEP 4)
ASSEMBLYING (POST)
(STEP 5)
INSPECTION
(STEP 6)
DELIVERY
(STEP 7)

FIG. 10

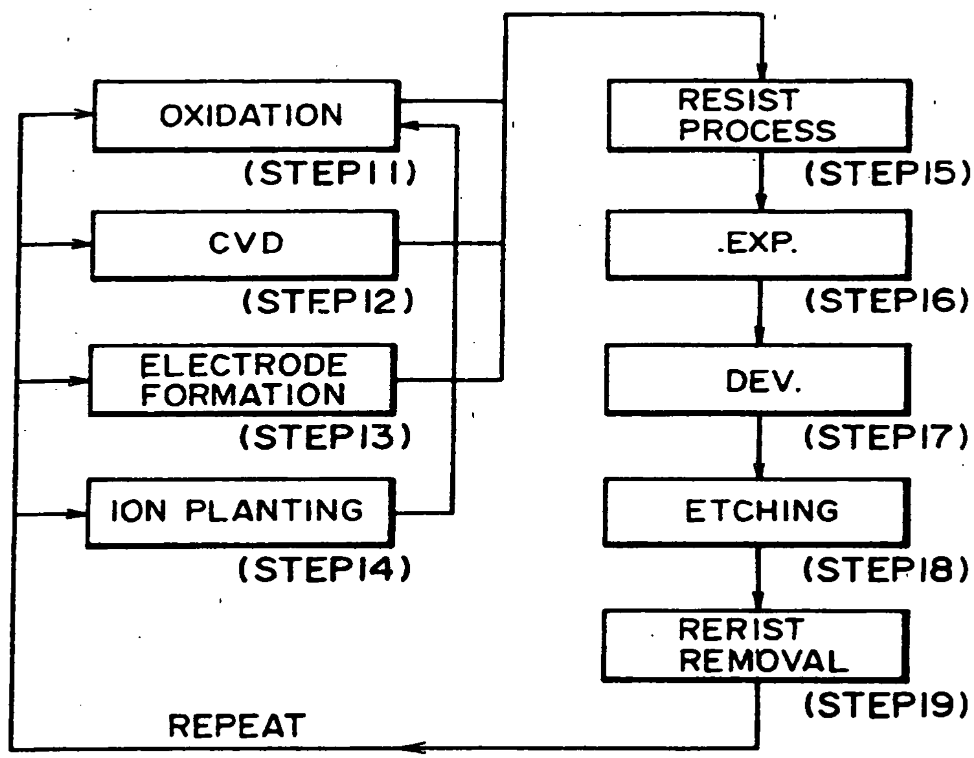
OXIDATION
(STEP11)
CVD
(STEP12)
ELECTRODE FORMATION
(STEP13)
ION PLANTING
(STEP14)
RESIST PROCESS
(STEP15)
.EXP.
(STEP16)
DEV.
(STEP17)
ETCHING
(STEP18)
RERIST REMOVAL
(STEP19)
REPEAT

FIG. 11

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 30 0447

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US-A-5 121 160 (SANO NAOTO ET AL) 9 June 1992 * column 7, line 5 - column 9, line 2 * * figures 4-8 *	7,9, 11-13	G03F7/20
A		1,5	

X	US-A-4 851 882 (TAKAHASHI KAZUHIRO ET AL) 25 July 1989 * abstract; figures * * column 7, last paragraph *	11-13	
A		1,5,7	

X	US-A-4 682 885 (TORIGOE MAKOTO) 28 July 1987 * abstract; figures * * column 3, line 61 - column 4, line 26 *	11-13	
A		1,5,7	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

G03F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 May 1995	Heryet, C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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